



Semester 1 2014 / 2015

Exam Code(s)	
Exam(s)	1 st Engineering
Module Code(s)	CH140
Module(s)	Engineering Chemistry
External Examiner(s)	Professor Tim Gallagher
Internal Examiner(s)	Professor P.V. Murphy *Dr. P. O'Leary

INSTRUCTIONS: Answer Four questions:
Question one must be attempted (-0.5 for incorrect answer)
Three other questions must be attempted
Separate Answer Books are not required for each section.
All questions carry 25 marks distributed as shown.

Leave the front page of the Answer Book blank and clearly list on it the numbers of the questions attempted.

Duration	2hrs
No. of Pages	6 (including this front page)
Department(s)	Chemistry

Requirements None

All questions carry equal marks.
Molar volume at STP= 22.4 dm³, Avogadro's Number 6.02 x 10²³,
R=0.08206 dm³ atm/mol K

Section A

1. Answer each of the following [by indicating the correct answer in your answer book]:

- (i) A sample of matter that can be decomposed into three different elements
a. must be a solution.
b. must be a compound.
c. must be a heterogeneous mixture.
d. must be a homogeneous mixture.
e. could be any of the preceding four answers. **[2 Marks]**
- (ii) Each response below lists an ion by name and by chemical symbol or formula. Also each ion is classified as monatomic or polyatomic and as a cation or anion. Which response contains an error?
a. hydroxide OH^- monatomic anion
b. carbonate CO_3^{2-} polyatomic anion
c. ammonium NH_4^+ polyatomic cation
d. magnesium Mg^{2+} monatomic cation
e. sulfite SO_3^{2-} polyatomic anion **[2 Marks]**
- (iii) What element has the electron configuration $[\text{Kr}] 4d^5 5s^1$?
(a) W
(b) Ru
(c) Mo
(d) Pm **[2 Marks]**
- (iv) A compound is known to contain only carbon, hydrogen, and oxygen. If the complete combustion of a 0.150 g sample of this compound produces 0.225 g of CO_2 and 0.0614 g of H_2O , what is the empirical formula of this compound?
a. C_3H_4
b. CH_4O
c. C_3HO_3
d. $\text{C}_3\text{H}_4\text{O}_3$
e. $\text{C}_5\text{H}_7\text{O}_5$ **[2 Marks]**
- (v) Which combination of name and formula below is correct?
(a) sodium acetate, CH_3COONa
(b) lithium oxide, LiO_2
(c) iron(II) chloride, FeCl_3
(d) potassium hydrogen sulfate, K_2SO_4 **[2 Marks]**
- (vi) Maleic acid, which is used to manufacture artificial resins, has the empirical formula CHO . Its molar mass is 116.1 g/mol. What is its molecular formula?
(a) CHO
(b) $\text{C}_2\text{H}_2\text{O}_2$
(c) $\text{C}_3\text{H}_3\text{O}_3$
(d) $\text{C}_4\text{H}_4\text{O}_4$ **[2 Marks]**

- (vii) Nitrogen oxide is oxidized in air to give brown nitrogen dioxide.
 $2 \text{NO(g)} + \text{O}_2\text{(g)} \rightarrow 2 \text{NO}_2\text{(g)}$

If you have 2.2 moles of NO,

(a) you need 2.2 moles of O_2 for complete reaction and produce 2.2 moles of NO_2 .

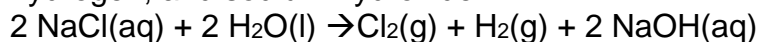
(b) you need 1.1 moles of O_2 for complete reaction and produce 2.2 moles of NO_2 .

(c) you need 1.1 moles of O_2 for complete reaction and produce 3.3 moles of NO_2 .

(d) you need 1.0 moles of O_2 for complete reaction and produce 2.0 moles of NO_2 .

[2 Marks]

- (viii) Electrolysis of aqueous sodium chloride is an important industrial process, since the products are commercially important chlorine, hydrogen, and sodium hydroxide.



Assuming you begin with 293 g of NaCl how many grams of Cl_2 are theoretically obtainable?

(a) 71.0 g

(b) 147 g

(c) 178 g

(d) 710. g

[2 Marks]

- (ix) We have dissolved 2.335 g of $\text{K}_2\text{Cr}_2\text{O}_7$ (molar mass = 294.18 g/mol) in enough water to make 500. mL of solution. What is the molarity of the potassium dichromate?

(a) $1.59 \times 10^{-5} \text{ M}$

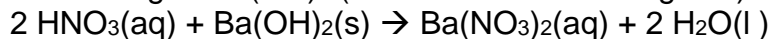
(b) 0.00794 M

(c) 0.0318 M

(d) 0.0159 M

[2 Marks]

- (x) How many milliliters of 0.125 M HNO_3 are required to react completely with 1.30 g of Ba(OH)_2 (molar mass = 171.34 g/mol)?



(a) 1.90 mL

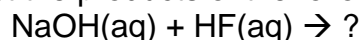
(b) 60.7 mL

(c) 356 mL

(d) 121 mL

[2 Marks]

- (xi) Predict the products of the following acid-base reaction:



(a) $\text{NaF(aq)} + \text{H}_2\text{O(l)}$

(b) $\text{NaH(aq)} + \text{HOF(aq)}$

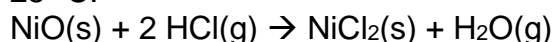
(c) $\text{OH}^-\text{(aq)} + \text{NaF(aq)}$

(d) no reaction takes place

[2 Marks]

....Question continues overleaf

- (xii) Given the following information, calculate ΔG° for the reaction below at 25 °C.



$$\Delta H^\circ = -122.8 \text{ kJ and } \Delta S^\circ = -125.4 \text{ J/K}$$

- (a) -85.4 kJ
- (b) -160.2 kJ
- (c) -119.7 kJ
- (d) 126.7 kJ

[3 Marks]

2. Answer each of the following:

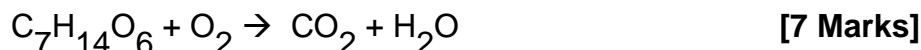
- (i) Neryl acetate was found to contain 73.4% C, 10.3% H the remainder being O. What is its empirical formula? **[7 Marks]**

- (ii) If its molecular mass is 196.32 amu what is its molecular formula **[3 Marks]**

- (iii) Write a chemical formula for the named chemicals (a)-(d). In each case also show the charge on the cation and anion. For the chemical formulas (e)-(h) write the name of the compound

- | | |
|-------------------------|-----------------------------|
| (a) Calcium chloride | (e) AgCl_2 |
| (b) Copper(I)oxide | (f) Fe_2O_3 |
| (c) Potassium sulfate | (g) K_2CO_3 |
| (d) Magnesium hydroxide | (h) NaI |
- [8 Marks]**

- (iv) Balance the following equation showing the process by which you balanced it



3. Answer each of the following:

10g of NaOH were dissolved in 1.5 L of water. 10 mL of this solution was titrated with a H_2SO_4 solution of unknown concentration. The endpoint was reached when 12.5 mL of the acid was added.

- (i) What method could be used to detect the endpoint of the reaction? **[5 Marks]**

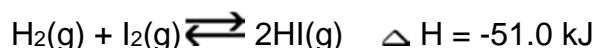
- (ii) What is the concentration of the NaOH solution which was made up? **[6 Marks]**

- (iii) How many moles of NaOH are present in the 10mL that were used in the titration? **[4 Marks]**

- (iv) What is the balanced equation for the reaction? **[5 Marks]**

- (v) From the results given calculate the concentration of the H_2SO_4 solution **[5 Marks]**

4. Answer each of the following:

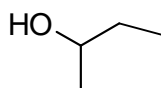


- (i) The synthesis of Hydrogen iodide (HI) is based on the equilibrium process shown here. Explain Le Chatelier's principle as it applies to the synthesis of HI. In doing so outline the effect on the position of equilibrium of lowering the temperature or increasing the pressure or removing HI as it is formed. **[9 Marks]**
- (ii) What is entropy? Discuss what role it plays in determining if a reaction is spontaneous or not. **[4 Marks]**
- (ii) What is the effect on the rate of a reaction of the following? In each case explain why this is the case
- (a) decrease in pressure (gas phase reaction)
 - (b) decrease in pressure (solid phase reaction)
 - (c) moving from solid phase to gas phase reaction of same materials
 - (d) increase in temperature

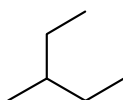
[4 x 3 Marks]

5. Answer each of the following:

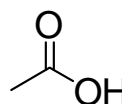
- (i) Draw structural formulae showing all the atoms of *both* of the following: 2,3-diethylheptanal, 2-chloro-bromobenzene **[5 marks]**



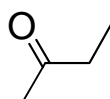
(i)



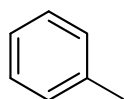
(ii)



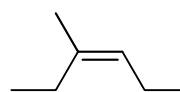
(iii)



(iv)



(v)



(vi)

- (ii) Name each molecule and indicate the functional group present in the molecules above (i)-(vi): **[2 x 6 marks]**
- (iii) A vessel containing a sample of gas is at 3.2 atm pressure, 100 °C and has a volume of 4 dm³. What pressure would be present when the temperature is changed to 35°C and the volume to 3.5 dm³? How many moles of the gas are present in the sample? **[8 Marks]**

1																	18																		
1 H 1.00794																	2 He 4.002602																		
3 Li 6.941		4 Be 9.012182												5 B 10.811		6 C 12.0107		7 N 14.00674		8 O 15.9994		9 F 18.9984032		10 Ne 20.1797											
11 Na 22.989770		12 Mg 24.3050												13 Al 26.581538		14 Si 28.0855		15 P 30.973761		16 S 32.066		17 Cl 35.4527		18 Ar 39.948											
19 K 39.0983		20 Ca 40.078		21 Sc 44.955910		22 Ti 47.867		23 V 50.9415		24 Cr 51.9961		25 Mn 54.938049		26 Fe 55.845		27 Co 58.933200		28 Ni 58.6534		29 Cu 63.545		30 Zn 65.39		31 Ga 69.723		32 Ge 72.61		33 As 74.92160		34 Se 78.96		35 Br 79.504		36 Kr 83.80	
37 Rb 85.4678		38 Sr 87.62		39 Y 88.90585		40 Zr 91.224		41 Nb 92.90638		42 Mo 95.94		43 Tc (98)		44 Ru 101.07		45 Rh 102.90550		46 Pd 106.42		47 Ag 196.56655		48 Cd 112.411		49 In 114.818		50 Sn 118.710		51 Sb 121.760		52 Te 127.60		53 I 126.90447		54 Xe 131.29	
55 Cs 132.90545		56 Ba 137.327		71 Lu 174.967		72 Hf 178.49		73 Ta 180.94.79		74 W 183.84		75 Re 186.207		76 Os 190.23		77 Ir 192.217		78 Pt 195.078		79 Au 196.56655		80 Hg 200.59		81 Tl 204.3833		82 Pb 207.2		83 Bi 208.58038		84 Po (209)		85 At (210)		86 Rn (222)	
87 Fr (223)		88 Ra (226)		103 Lr (262)		104 Rf (261)		105 Db (262)		106 Sg (263)		107 Bh (262)		108 Hs (265)		109 Mt (266)		110 Ds (269)		111 Rg (272)		112 Cn (277)		113 Uut (277)		114 Uuq (277)		115 Uup (277)		116 Uuh (277)		118 Uuo (277)			